

Risks of inappropriate use of glyphosate in coffee groves

Ing. Agr. Primo L. Chavarría, Ph.D.

Innovación Agroambiental S.A.

primol87@yahoo.es

Tel. (506) 8349-9911 / 2710-5245

[Dr Chavarría is a Costa Rican agronomist and academic with many years' experience in weed science]

Presented 27th April 2017, San José, at workshop organised by IRET, National University (UNA) as part of the SAICM-funded project on *Highly Hazardous Pesticide phase out and alternatives in Costa Rica.*

Objectives

- ▶ Share information and opinions
- ▶ Review conventional concepts [of weed control]
- ▶ Warn of the risks from glyphosate spraying
- ▶ Collaborate and propose alternatives
- ▶ Stimulate discussion

1st proposition: a nice, productive farm



Weed management concept

A set of practices carried out to avoid harmful effects of weeds on coffee production

Implications of this concept:

- ▶ Direct efforts towards plant species proven to be harmful
- ▶ Take account of crop characteristics and needs at each growth stage
- ▶ Define a management plan with long term vision
- ▶ Make intelligent use of available resources
- ▶ Always work for the benefit of the crop (don't carry out practices which can harm it)

Scenarios



1. Excellent



2. Good



3. Poor

Initial symptoms



Traditional application



Reference base

Weed type characterisation, according to botanical classification or leaf type:

Narrow-leaved	Broad-leaved
Grasses (Graminaceae)	Erect
Rushes & Sedges (Cyperaceae)	Climbing
	Prostrate (mat-forming)

Or according to effects in coffee groves:

- ▶ Harmful
- ▶ Innocuous (neutral)
- ▶ Beneficial

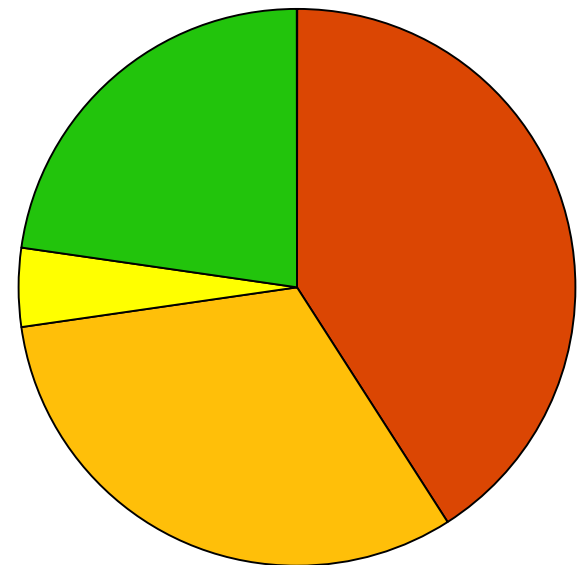
Characterising effects

- **Studies in Colombia** (Gómez y Rivera 1987; Gómez 1990; Rivera 1997; Salazar e Hincapié, 2005)

170 species studied:

- 76 very harmful (45% in brown)
- 59 intermediate effect (35% in green)
- 9 very little effect (5% in yellow)
- 25 beneficial (15% in orange)

■ Muy nocivas
■ Efecto intermedio



Why? Because they are: (a) very competitive, with abundant, fibrous root systems

(b) allelopathic, releasing poisonous substances into the soil

Examples of harmful weeds:



*Eleusine
indica*



*Paspalum
paniculatum*



*Digitaria
abyssinica*

Why? Because they are:

(a) very competitive, with abundant, fibrous root systems

(b) allelopathic, releasing poisonous substances into the soil

Examples of beneficial weeds:



Hydrocotyle blowesioides



Dichondra repens



Euphorbia postrata

Why? Because they:

- (a) help avoid soil erosion
- (b) encourage a stable microbial community
- (c) provide suitable microclimate for coffee bush roots
- (d) prevent establishment of harmful weed species

Comparison of effects



2 coffee bushes of equal age

Allelopathy



Features of conventional weed control

- ▶ Aims for total control
- ▶ Becomes an end in itself
- ▶ Resorts to abusive applications
- ▶ Pushes farmer into a 'vicious circle' of repeated herbicide spraying
- ▶ Fails to achieve qualitative progress
- ▶ Aggressive to the environment
- ▶ Ends up with mistakes which can jeopardise coffee bush health

Herbicides as a management resource

- ▶ Lots of pros and some cons
- ▶ Have made a marked difference to increasing production (more capacity to manage large areas)
- ▶ Products are phytotoxic by definition [i.e. ability to harm any plant]
- ▶ Their use should be very carefully considered
- ▶ Selective effects depend on many factors, especially in mode of application

Avoiding contact with the crop is always advisable



The glyphosate case

- ▶ The most successful herbicide in history
- ▶ Generalised acceptance
- ▶ Lack of understanding of its characteristics (overconfidence in use; risky applications)
- ▶ Sociopolitical controversy ('all against Monsanto'; in defence of public health?)

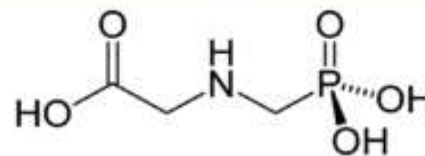
Historical overview

Background: discovered in 1950 by Swiss chemist Henri Martin of Cilag company, which abandoned glyphosate because they could find no pharmaceutical use

**Today: over 2,000
glyphosate
products used
worldwide**

Rediscovered: in 1970 by John Franz of Monsanto, looking for substances to decalcify water, who then realised its potential for herbicidal activity. It was patented in 1971 until 2000.

Glyphosate



N-fosfono-metil-glicina

Glyphosate characteristics

Desirables

Effective (overwhelmingly)

Good toxicological profile

Good environmental profile

Rapidly inactivates in soil

Cheap

Undesirables

Not selective for any crop

Does not present specific symptoms [of phytotoxicity]

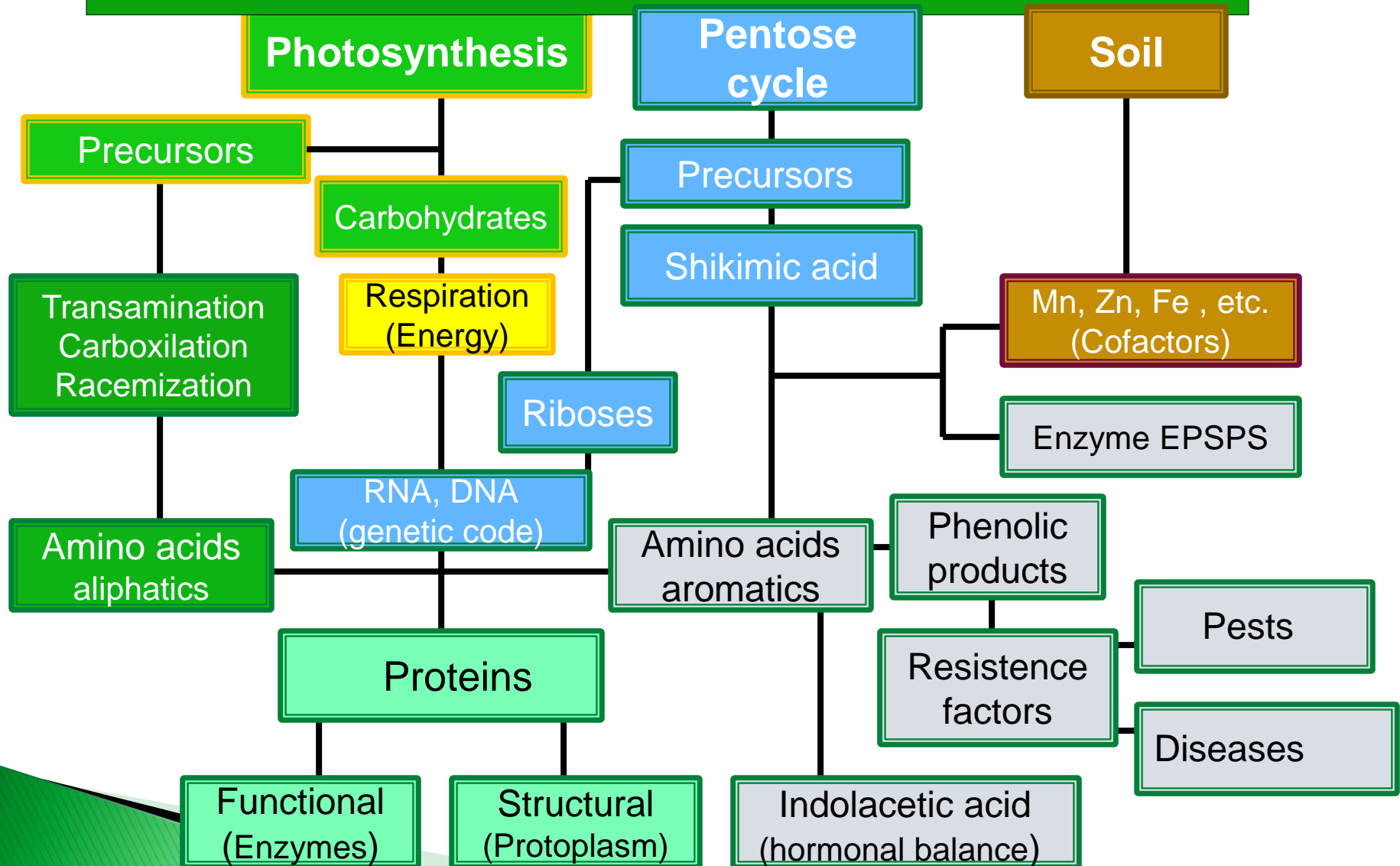
Very persistent in plant tissue

Difficult detoxification

Dangerous to crops exposed to glyphosate products

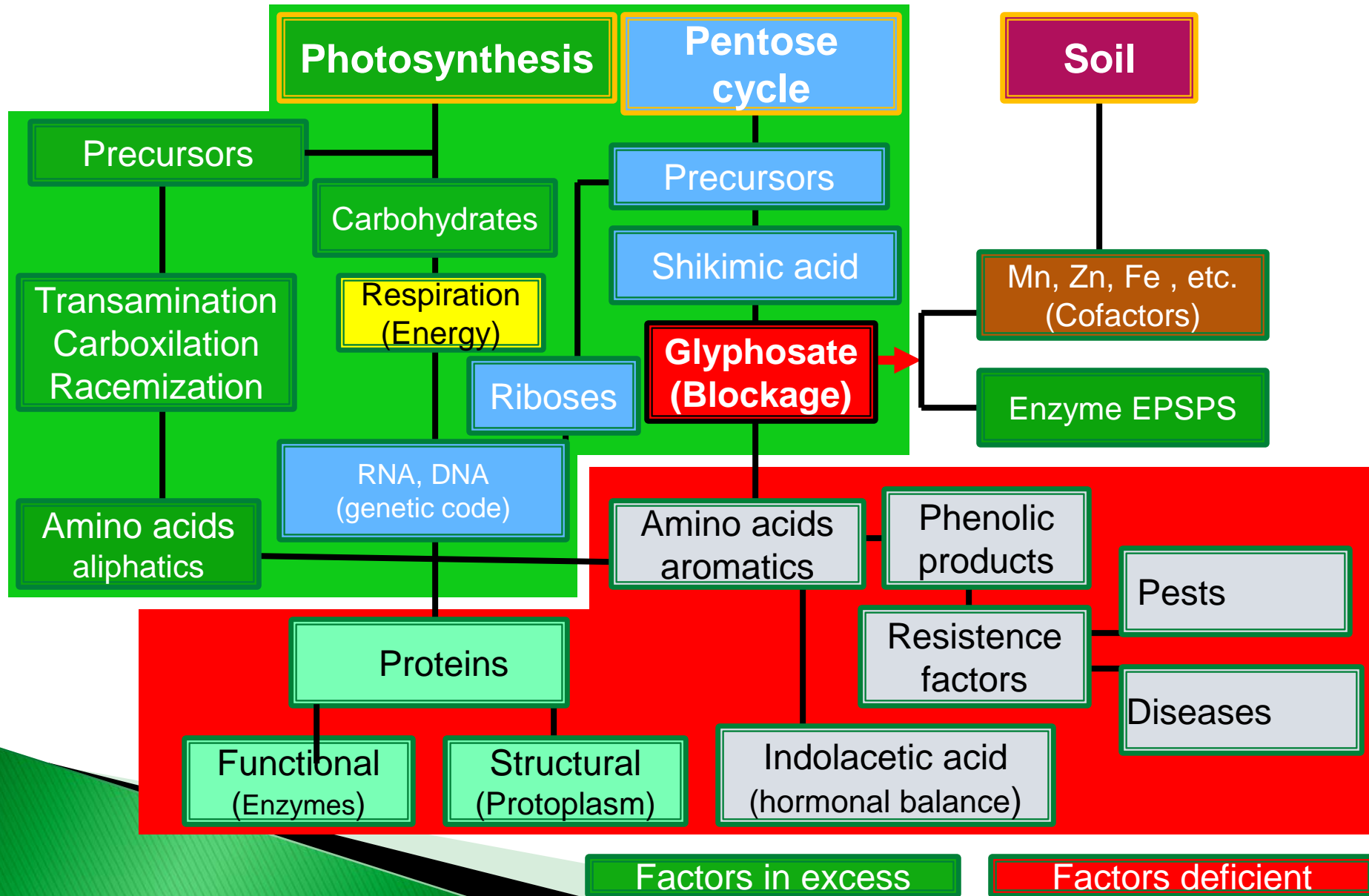
Metabolic interactions in plants: Conceptual framework

Source: PL Chavarría, unpublished, 21/05/2015



Glyphosate effects in plants

Source: PL Chavarría, unpublished, 21/05/2015



Possible consequences

[of unintended crop exposure to glyphosate]

- Plant growth is paralysed – due to deficiency in structural proteins
- Generalised metabolic alterations – due to deficiency in enzymes
- Phenological disturbances – due to hormonal imbalance
- Increased pest incidence – due to (a) deficiency in [plant-protective] secondary metabolites and (b) accumulation of carbohydrates and aliphatic amino acids
- Increased incidence and virulence of plant diseases – due to deficiency in plant resistance factors (phytoalexins, salicylic acid, lignin)

Other consequences

Alterations to water and nutrient balance [in the plant]

- Limited absorption due to malfunctioning roots (lack of root hairs)
- Root rotting due to pathogens and saprophytes
- Plant dehydration and susceptibility to drought
- Sequestering of bivalent cations (manganese, magnesium, zinc, iron, nickel)
- Xylem blockages due to pathogens (*Xylella fastidiosa*)

Mineral deficiencies in *Gmelina*



Further consequences

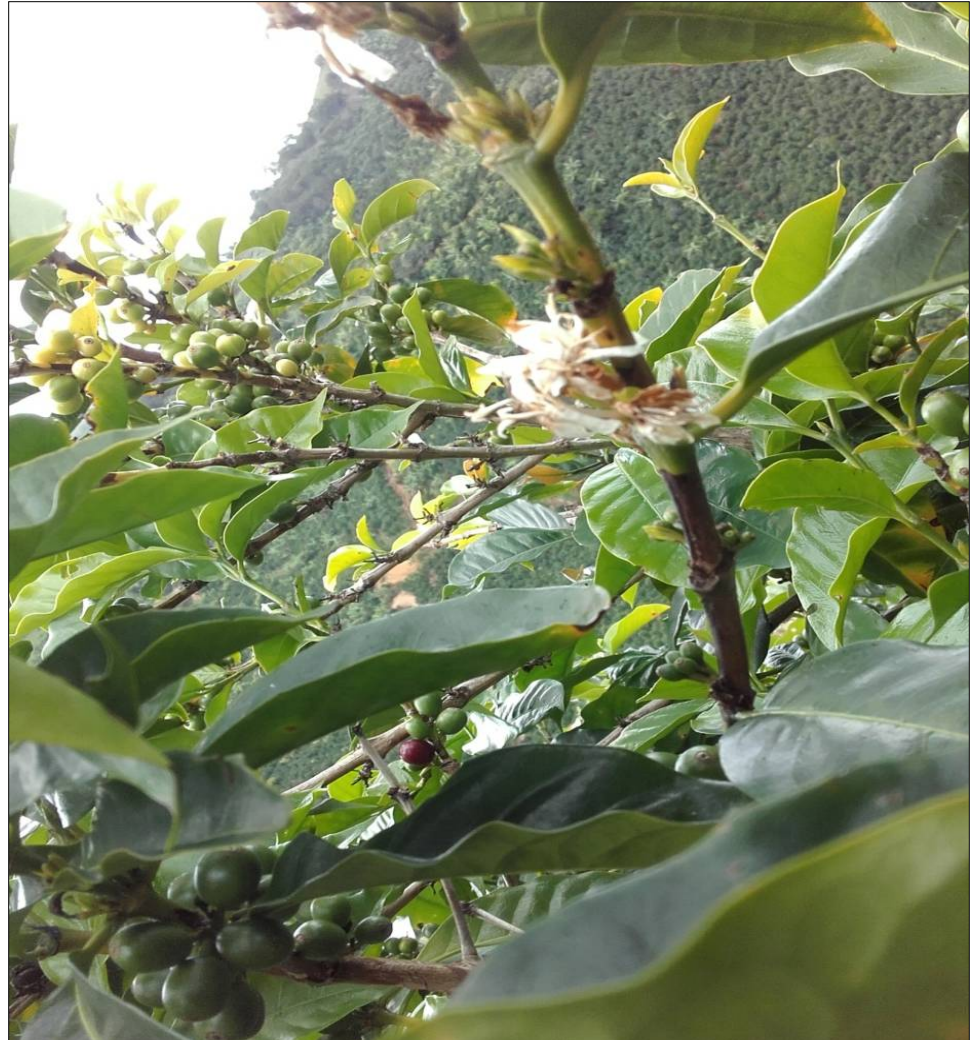
Phenological imbalances:

- Growth suspended
- Untimely and irregular flowering induced
- Irregular proliferation of primordial meristems
- Premature aging of tissues
- Reduction in useful life span of perennial crops

Hormonal imbalance

Coffee bushes observed at different phenological stages at the same time (flower buds, flowers, green, ripening and maturing berries on the same bush!)

*San Marcos de Tarrazú,
29 August, 2015*



Frequent effects

Poisoning patterns in coffee plots



Repeated poisoning



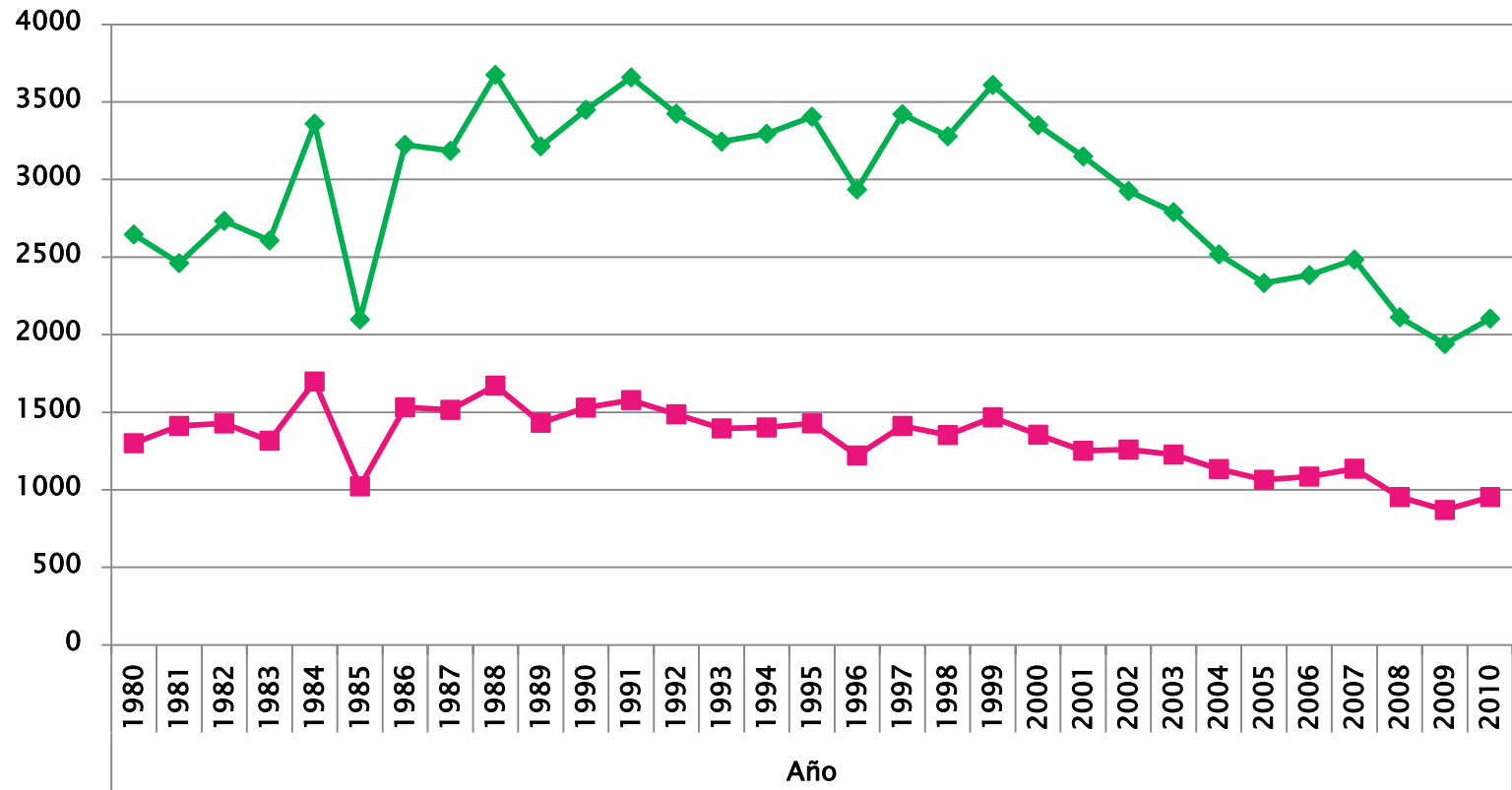
Misdiagnosis as fungal disease symptoms ???



Consequences

Total coffee production (thousands of fanegas/year) and productivity(kg/ha/yr) in Costa Rica (1980-2010) .

Source: ICAFE



Equipment and application modes



Proposal: 'Eco-weeder' = ecological weed controller

i.e a hand-held tool to selectively apply herbicide



Proposal: 'Eco-weeder' = ecological weed controller

Defined as:

'an instrument designed to apply systemic herbicides in a very precise and economical way, minimising risks to the crop, worker exposure and environmental contamination'

Advantages of using the 'Eco-weeder'

- ▶ **Herbicide is only applied to weeds which the farmer wants to get rid of**
- ▶ **Less than half of normal herbicide volume is needed**
- ▶ **It allows the operator to select and conserve vegetative cover plants**
- ▶ **It helps productive, environmental and economic sustainability**
- ▶ **Based on modern scientific concepts (awarded National Technology Prize in 2008)**

Ground cover vegetation: the convenient option



Conclusions

1. Glyphosate possesses exceptional characteristics which have made it the most successful herbicide in history
2. Nevertheless, inappropriate use involves very important risks for coffee and other crops where glyphosate has been used
3. These risks can be minimised via applications which guarantee that the herbicide does not come into contact with the crop foliage
4. The 'Eco-weeder' tool enables application of systemic herbicides, including glyphosate, avoiding crop contact, environmental contamination or worker exposure

Problem ?



Rational weed management

Neither in excess nor insufficient



Author's concluding remarks (a)

Based on evidence from the literature, as well as personal observations over several years, the author considers that inappropriate glyphosate applications have resulted in adverse effects in several crops, including coffee and banana. These are probably associated with reductions in productivity documented in recent years in these crops.

Nevertheless, there could be other accompanying factors or which derive from this initial effect- these relationships have not been clearly established due to lack of research which look at this problem from an integrated perspective.

Author's concluding remarks (b)

The conceptual framework presented here in Figs 1 and 2 forms an attempt which can serve as a basis for visualising the consequences which could result from initial effects of glyphosate, as well as possible interactions related to problems linked to different disciplines (weed management, phytopathology, mineral nutrition, plant physiology, genetics, etc.)

As a result, this framework could serve as a basis for conducting interdisciplinary research which could provide information to enable a better understanding of all the problems linked with unsuitable use of this herbicide.

Author's concluding remarks

(c)

Meanwhile, it seems quite clear the need to warn agronomy professionals about the probably risks associated with inappropriate use of glyphosate, so that they can help farmers avoid the poor application practices, which many currently carry out. Likewise, the competent authorities should be aware of the issues and be prepared to take measures to correct the problems, once sufficient proof exists to unequivocally confirm the need for action.

In this case, [unwanted] effects on any interested party should be avoided but above all, protection of farmers' interests should prevail to prevent them from unintentionally making mistakes which jeopardise their efforts to produce more and better.

Immediate research questions

1. Determine to what extent glyphosate affects mineral nutrition of coffee bushes, especially in relation to root functionality.
2. Find out whether applying nutrients before or after herbicide can modify the severity of effects.
3. Explore the possible relationship between glyphosate applications and the incidence of coffee diseases, especially *Xylella fastidiosa*.

Other questions

- 4. Evaluate the feasibility of new methods for applying glyphosate, to minimise crop exposure.**
- 5. Quantify the risks from spraying glyphosate in comparison with more costly alternatives (glufosinate ammonium)**
- 6. Determine the suitability of using ground cover plants and identify the best species for avoiding soil erosion.**